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(54) **TRANSMITTER AND TRANSVERSAL FILTER**

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a transmitter for transmitting an OFDM (orthogonal frequency division multiplexing) signal whose out-of-band radiation level is reduced under the condition that satisfies a Nyquist first reference and prevents the occurrence of an inter-code interference.

SOLUTION: In this transmittera serial/parallel converter 1 converts a transmission symbol string of one sequence into a parallel transmission symbol string of L (the number of subcarriers) sequences. An IFT 2 converts the parallel transmission symbol string of L sequences into an OFDM signal. I and Q channel signals of conversion results are subjected to spectral shaping by root rolloff filters 3I and 3Qand theninputted to multipliers 4I and 4Q to be orthogonally modulated. In a receiver sideI and Q channel signals of orthogonal demodulation signals outputted from multipliers 9I and 9Q are subjected to spectral shapings by root rolloff filters 11I and 11Q and then inputted to an FT part 12.

CLAIMS

[Claim(s)]

[Claim 1]

An inverse Fourier transform means to input a parallel transmission symbol string and to output an OFDM signal

A transmission filter which band-limits by inputting said OFDM signal outputted from this inverse Fourier transform means

It is a sending set which has a transmitting means which outputs a sending signal transmitted to a receiving set by carrying out quadrature modulation of the output of this transmission filter

Comprehensive transmission characteristics including a receiving filter by the side of said receiving set are roll-off characteristics which meet the 1st standard of nyquist
Said transmission filter is the characteristic to which some roll-off characteristics which meet said 1st standard of nyquist were distributedand it has the characteristic of reducing an out-of-band radiation level of said OFDM signal which said inverse Fourier transform means outputs
A sending set characterized by things.
[Claim 2]
The sending set according to claim 1wherein the characteristic of said transmission filter is the characteristic which carried out equipartition of the roll-off characteristics which meet said 1st standard of nyquist between said receiving filters.
[Claim 3]
The sending set according to claim 1 or 2wherein roll-off characteristics which meet said 1st standard of nyquist are square cosine roll-off characteristics.
[Claim 4]
Said comprehensive transmission characteristic in a transition region of roll-off characteristics which meet said 1st standard of nyquistA basic transfer function used as roll-off characteristics which meet said 1st standard of nyquistTo center frequency of said transition regionit is the sum with 1 or two or more amendment transfer functions which are an odd functionand is expressed with a transfer function amended so that it might have the characteristic of reducing an out-of-band output-signal-power level rather than said basic transfer function
The characteristic of said receiving filter is expressed with a transfer function with which said a part of basic transfer function was distributed
The characteristic of said transmission filter is expressed with a transfer function which did division of the transfer function of said comprehensive transmission characteristic with a transfer function of said receiving filter
The sending set according to claim 1 characterized by things.
[Claim 5]
Each weighting factor of a weighting factor of said basic transfer function in said transition region and said 1or two or more amendment transfer functionsIt considers that said out-of-band radiation level is an integral value of power flux density in a frequency domain exceeding predetermined boundary frequency of a side out of bandand it is optimized so that this out-of-band radiation level may serve as the minimum
The sending set according to claim 4 characterized by things.
[Claim 6]
Said predetermined boundary frequency is within the limits of a transition region of roll-off characteristics which meet said 1st standard of nyquistand it is set as frequency which is in slippage out of band rather than center frequency of this transition region
The sending set according to claim 5 characterized by things.

[Claim 7]
Said 1 or two or more amendment transfer functions in said transition region turn into the oddth cosine function
A transfer function of said comprehensive transmission characteristic is continuing in each frequency of both ends of said transition region
A sending set given in any 1 paragraph to claims 4-6 characterized by things.
[Claim 8]
A sending set given in any 1 paragraph to claims 4-7wherein said basic transfer function is square cosine roll-off characteristics.
[Claim 9]
This comprehensive transmission characteristic is a transversal filter which realizes the characteristic distributed among other filters so that a comprehensive transmission characteristic may turn into roll-off characteristics which meet the 1st standard of nyquist
Said comprehensive transmission characteristic in a transition region of roll-off characteristics which meet said 1st standard of nyquistA basic transfer function used as roll-off characteristics which meet said 1st standard of nyquistIt is the sum with 1 expressed with an odd function to center frequency of said transition regionor two or more amendment transfer functionsand is expressed with a transfer function amended so that it might have the characteristic of reducing an out-of-band output-signal-power level rather than said basic transfer function
The characteristic of a filter besides the above is expressed with a transfer function with which said a part of basic transfer function was distributed
A tap coefficient is set up so that the characteristic of said transversal filter may be expressed with a transfer function which did division of the transfer function of said comprehensive transmission characteristic with a transfer function of a filter besides the above
A transversal filter characterized by things.
[Claim 10]
Each weighting factor of a weighting factor of said basic transfer function in said transition region and said 1or two or more amendment transfer functionsIt considers that said out-of-band output-signal-power level is an integral value of power flux density in a frequency domain exceeding predetermined boundary frequency of a side out of bandand it is optimized so that this out-of-band output-signal-power level may serve as the minimum
The transversal filter according to claim 9 characterized by things.
[Claim 11]
Said predetermined boundary frequency is within the limits of a transition region of roll-off characteristics which meet said 1st standard of nyquistand it is set as frequency which is in slippage out of band rather than center frequency of this transition region
The transversal filter according to claim 10 characterized by things.
[Claim 12]
Said 1 or two or more amendment transfer functions in said transition region turn

into the oddth cosine function
A transfer function of said comprehensive transmission characteristic is continuing in each frequency of both ends of said transition region
A transversal filter given in any 1 paragraph to claims 9-11 characterized by things.
[Claim 13]
A transversal filter given in any 1 paragraph to claims 9-12wherein said basic transfer function is square cosine roll-off characteristics.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
A sending set which uses this invention in an OFDM (Orthogonal Frequency Division Multiplexing: orthogonal frequency division multiplex) communications systemAnd it is related with the transversal filter which reduces an out-of-band output-signal-power levelwithout generating intersymbol interference.
[0002]
[Description of the Prior Art]
In various radio communications systemssuch as wireless LAN (refer to an IEEE802.11a standard and the nonpatent literature 1)a digital sounda video communication systemthe OFDM communication technology using two or more subcarriers which intersect perpendicularly is used.
Drawing 9 is a block lineblock diagram of the conventional OFDM communication system.
A deserializer and 2 are the IFT (Inverse Fourier Transform: inverse Fourier transform) sections one among a figure. As a transmission symbol (complex number) sequence after digital modulation (BPSKQPSK16QAMetc.) was carried outsend data is inputted into the deserializer 1is changed into the parallel transmission symbol (complex number) sequence of L bookand is outputted to IFT2.
HereL is the number of subcarriers of an OFDM signal. That isthe deserializer 1 specifies the complex amplitude of the signal which modulates each subcarrier which is in orthogonality relation mutually by a parallel transmission symbol (complex number) sequence. IFT2 generates the waveform corresponding to each complex amplitude of the subcarrierand it outputs I OFDM signals [Q] (real part) (imaginary part) independently. IFT2 usuallyIt realizes by digital signal processing using IDFT(s) (Inverse Discrete Fourier Transform: discrete inverse Fourier transform)such as IFFT (Inverse Fast Fourier Transform: fast inverse Fourier transform).
[0003]
As for an amplitude control partand 4I and 4Qas for a multiplier and 541 is [an adding machine and 7] transmission lines a career (subcarrier) signal oscillator

and 6.
The amplitude control part 41 attenuates amplitude for the OFDM signal according to I channel outputted from IFT2and Q channel smoothly on the boundary of each symbolrespectively. Specificallyit mentions later with reference to drawing 10.
Quadrature modulation of the time base waveform of I channel by which amplitude control was carried out is carried out. That isin the multiplier 4Imultiplication is carried out to the output of the career (subcarrier) signal oscillator 5 in phaseand it is outputted to the adding machine 6. On the other handin the multiplier 4Qthe multiplication of the Q channel time axial-wave type by which amplitude control was carried out is carried out to pi / 2 phase-shift output of the carrier signal oscillator 5and it is outputted to the adding machine 6. The adding machine 6 outputs the thing adding the output of the multipliers 4I and 4Q to the transmission line 7 as an OFDM signal.
[0004]
When using IDFT for IFT2 and also realizing the amplitude control part 41 by digital processingafter the output of the amplitude control part 41 is changed into an analog signal with the D/A converter which is not illustratedit is supplied to the multipliers 4I and 4Q.
In an actual equipment configurationa summed signal turns into a signal of a high frequency band (RF) directlyis outputted to the transmission line 7or once it turns into a signal of an intermediate frequency band (IF)and frequency conversion is carried out to a high frequency band (RF) after thisand it is outputted to the transmission line 7 (radio transmission line).
Usuallythe graphic display is omitted although guard time is inserted in the head part of 1 symbol section of an OFDM signal. The above is the composition by the side of a transmitter.
[0005]
In a receiver endthe reverse of processing by the side of a transmitter is performed. As for 8as for a teeand 9I and 9Qa multiplier and 10 are carrier signal oscillators. In a receiver endthe received OFDM signal is supplied to the multiplier 9I of an I channel systemand the multiplier 9Q of a Q channel system in the tee 8.
In each multipliers 9I and 9Qorthogonal demodulation of the received OFDM signal is carried out by carrying out multiplication to the output in phase from the carrier signal oscillator 10 which carries out phase simulation to the carrier signal oscillator 5 by the side of a transmitterand is oscillated on the same frequencyand pi / 2 phase-shift output. The OFDM signal of I channel by which orthogonal demodulation was carried outand Q channel is outputted to the FT (Fourier Transform: Fourier transform) section 12.
[0006]
The FT section 12 extracts the complex amplitude of the signal which modulates two or more subcarriers of each which constitute an OFDM signaland outputs it to the serializer 13. The serializer 13 outputs the serialized reception symbol (complex number) sequence. Based on the modulation method corresponding to the digital modulation by the side of a transmitterdigital demodulation of the

reception symbol (complex number) sequence is carried outand received data are obtained.
The FT section 12 is usually realized by digital signal processing using DFTs (Discrete Fourier Transform: discrete Fourier transform)such as FFT (Fast Fourier Transform: Fast Fourier Transform). When using DFTafter the output of the multipliers 9I and 9Q is changed into a digital signal with the A/D converter which is not illustratedit is supplied to the FT section 12.
[0007]
If the frequency spectrum of the time base waveform outputted from the IFT section 2 has dramatically many subcarriersit will approach the ideal frequency spectrum of rectangular shape. Howeverwhen there are not so many numbers of a subcarrierfrequency spectrum has spread. As the transmission line 7when using a radio transmission linethe spurious radiation level to the outside of the zone assigned to the communications system is restricted by the standard. Thereforea subcarrier can be stood to the limit of the assigned zone and there is a problem that the utilization efficiency of frequency falls.
After band-limiting the modulated each subcarrier beforehandit is possible to compound these. Howeversince it will become irregular within IFT2 when using IFT2this method is inapplicable.
[0008]
Thenin order to oppress the ingredient of an OFDM signal out of band conventionallyinserting the amplitude control part 41 shown in drawing 9 is known for p.10 of the nonpatent literature 1and 11for example.
Drawing 10 is an explanatory view of the window function for explaining the amplitude control (Windowing) by the side of a transmitter.
5152and 53 are windows which carry out multiplication to the OFDM signal of 3 adjoining symbol sectionsrespectively among a figure.
Each windows 5152and 53 of a graphic display are the window functions of the segment of time which has the time width of the range a little exceeding 1 symbol section of an OFDM signalrises smoothlyand falls smoothly. On the boundary of each symbol sectionthe waveform of an OFDM signal may be discontinuousand it may change with the value changes of the symbol transmitted. In such a casean out-of-band radiation ingredient occurs. Thenby carrying out the multiplication of the time base waveform and window function which IFT2 outputson the boundary of each symbol sectionan OFDM sending signal will decline smoothly andas a resultan out-of-band radiation ingredient decreases.
[0009]
Drawing 11 is a graph in the conventional OFDM communication system which shows an output-signal-power spectrum. The case where carried out the spectrum plastic surgery of the signal amplitude of the both ends of the one OFDM symbol section with the segment-of-time window function (rate 0.025 of a roll-off) of the square cosine (raised cosine)and amplitude limiting in 1 symbol section boundary is carried outand the case where such amplitude limiting is not carried out are shown. A horizontal axis is the frequency normalized so that the

symbol rate (a symbol/sec) of the original complex transmission symbol before serial parallel conversion is carried out by the deserializer 1 shown in drawing 9 might be set to 1.
A necessary zone required to transmit an OFDM signal is 0.5 of the normalized frequency mentioned above. The integral value of the power spectrum in the frequency band exceeding 0.5 serves as an out-of-band radiation level.
Reduction of the out-of-band radiation level is realized by amplitude control so that clearly from drawing 11. Howeverit cannot be said that it is still enough. In order to use an OFDM signal by wireless LANthere is a request that you want to reduce power flux density to about -60 dB at least. Since intersymbol interference occursit becomes impossible to maintain the orthogonality between subcarriers and a data rate must be lowered although an out-of-band radiation level is reduced if the rate of a roll-off of a segment-of-time window is enlargedfrequency utilization efficiency falls after all.
[0010]
The paper using analog filterssuch as a Butterworth filter and a Chebyshev filterhas also actually covered the filter in the nonpatent literature 1 mentioned above in the frequency domain as methods other than the window wing which mentioned above as suggestedbut. Since the modulating signal of the subcarrier near the zone boundary becomes unsymmetrical and stops meeting a Nyquist's criteria with the characteristic of the transition region of a filter when radiation out of band is carried out to the design reduced greatlyintersymbol interference occurs and a complex transmission symbol sequence is not thoroughly restored by a receiver.
[0011]
[Nonpatent literature 1]
Part 11: Wireless LAN. Medium Access Control (MAC). and Physical Layer (PHY). specifications High-speed. Physical Layer in the. 5 GHz Band<URL: HYPERLINK. "http:. //standards.ieee.org/getieee802/download/802.11a-1999.pdf"http://standards.ieee.org/getieee802/download/802.11a-1999.pdf>
[0012]
[Problem(s) to be Solved by the Invention]
This invention was made in order to solve the problem mentioned aboveand it meets the 1st standard of nyquistA sending set which transmits the OFDM signal with which the out-of-band radiation level was reduced under the conditions of not generating intersymbol interferenceAnd it aims at providing the transversal filter which can be used as a transmission filter of this sending set and which reduces an out-of-band output-signal-power level under the conditions of not generating intersymbol interference.
[0013]
[Means for Solving the Problem]
A comprehensive transmission characteristic characterized by comprising the following which is a sending set and includes a receiving filter by the side of said receiving set this inventionWhat it is roll-off characteristics which meet the 1st

standard of nyquistand said transmission filter is the characteristic to which some roll-off characteristics which meet said 1st standard of nyquist were distributedand has the characteristic of reducing an out-of-band radiation level of said OFDM signal which said inverse Fourier transform means outputs.
An inverse Fourier transform means to input a parallel transmission symbol string and to output an OFDM signal in the invention according to claim 1.
A transmission filter which band-limits by inputting said OFDM signal outputted from this inverse Fourier transform means.
A transmitting means which outputs a sending signal transmitted to a receiving set by carrying out quadrature modulation of the output of this transmission filter.

Thereforethe 1st standard of nyquist is met and an OFDM signal with which an out-of-band radiation level was reduced can be transmitted under conditions of not generating intersymbol interference.
[0014]
In the invention according to claim 2the characteristic of said transmission filter is the characteristic which carried out equipartition of the roll-off characteristics which meet said 1st standard of nyquist between said receiving filters in the sending set according to claim 1.
[0015]
In the invention according to claim 3roll-off characteristics which meet said 1st standard of nyquist are square cosine roll-off characteristics in the sending set according to claim 1 or 2.
[0016]
In the invention according to claim 4said comprehensive transmission characteristic in a transition region of roll-off characteristics which meet said 1st standard of nyquist in the sending set according to claim 1A basic transfer function used as roll-off characteristics which meet said 1st standard of nyquistIt is the sum with 1 or two or more amendment transfer functions which are an odd function to center frequency of said transition regionIt is expressed with a transfer function amended so that it might have the characteristic of reducing an out-of-band output-signal-power level rather than said basic transfer functionand the characteristic of said receiving filterIt is expressed with a transfer function with which said a part of basic transfer function was distributedand the characteristic of said transmission filter is expressed with a transfer function which did division of the transfer function of said comprehensive transmission characteristic with a transfer function of said receiving filter.
Thereforesince flexibility which determines the characteristic of a transition region rather than only changing a rate of a roll-off of a basic transfer function by using 1 or two or more amendment transfer functions increasesa design for obtaining the characteristic of reducing an out-of-band radiation level of an OFDM signal becomes easy.
If a periodic function which is an odd function and intersects perpendicularly to center frequency of a transition regionfor example is used as 1 or two or more

amendment transfer functionsa design will become easy further.
[0017]
On the invention according to claim 5 and in the sending set according to claim 4Each weighting factor of a weighting factor of said basic transfer function in said transition region and said 1or two or more amendment transfer functionsIt considers that said out-of-band radiation level is an integral value of power flux density in a frequency domain exceeding predetermined boundary frequency of a side out of bandand it is optimized so that this out-of-band radiation level may serve as the minimum.
Thereforethe characteristic of reducing an out-of-band radiation level of an OFDM signal easily can be obtained.
[0018]
In the invention according to claim 6in the sending set according to claim 5said predetermined boundary frequency is within the limits of a transition region of roll-off characteristics which meet said 1st standard of nyquistand is set as frequency which is in slippage out of band rather than center frequency of this transition region.
Thereforea rate of a roll-off of a basic transfer function can be substantially made smalland breadth of bandwidth can be stopped.
[0019]
In the invention according to claim 7said 1 or two or more amendment transfer functions in said transition region in a sending set given in any 1 paragraph to claims 4-6Becoming the oddth cosine functiona transfer function of said comprehensive transmission characteristic is continuing in each frequency of both ends of said transition region.
Thereforethe characteristic of reducing an out-of-band radiation level of an OFDM signal easily is realizable.
[0020]
In the invention according to claim 8said basic transfer function is square cosine roll-off characteristics in a sending set given in any 1 paragraph to claims 4-7.
[0021]
So that a comprehensive transmission characteristic may turn into roll-off characteristics which meet the 1st standard of nyquist in the invention according to claim 9This comprehensive transmission characteristic is a transversal filter which realizes the characteristic distributed among other filtersSaid comprehensive transmission characteristic in a transition region of roll-off characteristics which meet said 1st standard of nyquistA basic transfer function used as roll-off characteristics which meet said 1st standard of nyquistIt is the sum with 1 expressed with an odd function to center frequency of said transition regionor two or more amendment transfer functionsIt is expressed with a transfer function amended so that it might have the characteristic of reducing an out-of-band output-signal-power level rather than said basic transfer functionand the characteristic of a filter besides the aboveA tap coefficient is set up so that it may be expressed with a transfer function with which said a part of basic transfer

function was distributed and may be expressed with a transfer function to which the characteristic of said transversal filter did division of the transfer function of said comprehensive transmission characteristic with a transfer function of a filter besides the above.
Thereforethe 1st standard of nyquist can be met and a signal with which an out-of-band output-signal-power level was reduced can be outputted under conditions of not generating intersymbol interference. Since flexibility which determines the characteristic of a transition region rather than only changing a rate of a roll-off of a basic transfer function by using 1 or two or more amendment transfer functions increasesa design for obtaining the characteristic of reducing an out-of-band output-signal-power level becomes easy.
If a periodic function which is an odd function and intersects perpendicularly to center frequency of a transition regionfor example is used as 1 or two or more amendment transfer functionsa design will become easy further.
[0022]
On the invention according to claim 10 and in the transversal filter according to claim 9Each weighting factor of a weighting factor of said basic transfer function in said transition region and said 1or two or more amendment transfer functionsIt considers that said out-of-band output-signal-power level is an integral value of power flux density in a frequency domain exceeding predetermined boundary frequency of a side out of bandand it is optimized so that this out-of-band output-signal-power level may serve as the minimum.
Thereforethe characteristic of reducing an out-of-band output-signal-power level can be obtained easily.
[0023]
In the invention according to claim 11in the transversal filter according to claim 10said predetermined boundary frequencyIt is within the limits of a transition region of roll-off characteristics which meet said 1st standard of nyquistand is set as frequency which is in slippage out of band rather than center frequency of this transition region.
Thereforea rate of a roll-off of a basic transfer function can be substantially made smalland breadth of bandwidth can be stopped.
[0024]
On the invention according to claim 12 and in a transversal filter given in any 1 paragraph to claims 9-11Said 1 or two or more amendment transfer functions in said transition region turn into the oddth cosine functionand a transfer function of said comprehensive transmission characteristic is continuing in each frequency of both ends of said transition region.
Thereforethe characteristic of reducing an output signal level out of band easily is realizable.
[0025]
In the invention according to claim 13said basic transfer function is square cosine roll-off characteristics in a transversal filter given in any 1 paragraph to claims 9-12.

[0026]
[Embodiment of the Invention]
Drawing 1 is an explanatory view of a 1st embodiment of this invention. Drawing 1 (a) is a block lineblock diagramand drawing 1 (b) is an explanatory view of operation.
The same numerals are given to the same portion as drawing 9 of a conventional example among drawing 1 (a). The route roll-off filter (root roll-off filter) by the side of a transmitterand 11I and 11Q of 3I and 3Q are the route roll-off filters of a receiver end.
In the transmitter sidethe transmission symbol sequence of one series is changed into the parallel transmission symbol string of the series of L (number of subcarriers) book with the deserializer 1. The parallel transmission symbol string of the series of obtained L book is changed into an OFDM signal by IFT2. After spectrum plastic surgery (band-limited in a frequency domain) is carried out by the route roll-off filters 3I and 3Qquadrature modulation of I of a conversion result and the Q channel signaling is inputted and carried out to the multipliers 4I and 4Qand they acquire IF thru/or an RF signal.
[0027]
In a receiver endI of the orthogonal demodulated signal outputted from the multipliers 9I and 9Q and Q channel signaling are inputted into the FT section 12after spectrum plastic surgery is carried out by the route roll-off filters 11I and 11Q.
The enclosure portion directed with the numerals 14 shows among a figure a substantial transmission line until it is received via the transmission line 7 and the OFDM signal outputted from IFT2 by the side of a transmitter is inputted into FT12. Let the comprehensive transmission characteristic (multiplication of a transfer function) with which the characteristic of both the route roll-off filters 3I and 3Q by the side of a transmitter and the route roll-off filters 11I and 11Q of a receiver end was doubled be roll-off characteristics in this transmission line.
At this timethe route roll-off filters 3I and 3Q by the side of a transmitter are the characteristics to which some roll-off characteristics which meet the 1st standard of nyquist were distributedand have the characteristic of reducing the out-of-band radiation level of the OFDM signal which IFT2 outputs.
[0028]
The transfer function which added the transfer function which turns into an odd function to the cutoff frequency of an ideal low pass filter to the transfer function of this ideal low pass filter satisfies the 1st standard of nyquist.
The thing used as the characteristic of the transfer function continuing among the transfer functions to satisfyand the inclination of a transfer function to frequency also continuingand changing smoothly is called roll-off characteristics on these specifications. In particulara transition region calls the thing of a square cosine (raised cosine) square cosine roll-off characteristics.
Since a comprehensive transmission characteristic satisfies the 1st standard of nyquistthere is no inter symbol interference and a transmission symbol is

reproduced thoroughly. Under these conditionsan out-of-band radiation level can be reduced conventionally.

[0029]

You may be surprised that the communications system mentioned above can restore a transmission symbol sequence thoroughly. Thereforeas contrasted with the communications system of the conventional single career (single subcarrier) useit explains in detail.

Drawing 12 is a graph which shows the conventional block lineblock diagram and roll-off characteristics of a single career communications system as a comparative example.

Drawing 12 (a) is a block lineblock diagram of the conventional single career communications system which uses a route roll-off filter. Drawing 12 (b) is a graph which shows the transfer function of roll-off characteristics.

The same numerals are given to the same portion as drawing 9 among drawing 12 (a). The route roll-off filter by the side of a transmitterand 62I and 62Q of 61I and 61Q are the route roll-off filters of a receiver end.

The enclosure portion directed with the numerals 63 shows a substantial transmission line until it is received via the transmission line 7 and the complex transmission symbol sequence of one series is restored as a complex reception symbol sequence. In this substantial transmission lineroll-off characteristics are realized in this substantial transmission line by what the characteristic of both the route roll-off filter of the transmitter side and a receiver end is doubled for (multiplication of a transfer function).

[0030]

Drawing 12 (b) is a graph which shows the transfer characteristic of square cosine (raisedcosine) roll-off characteristics. A horizontal axis is normalized frequency and a vertical axis is an output (linear scale). It is symmetrical although normalized frequency is omitting the graphic display about the negative near characteristic. Normalization of frequency is normalized so that the symbol rate (reciprocal of a symbol interval) of a transmission symbol sequence may be set to 1. At this timethe frequency to which an output level falls to one half (6 dB) is 0.5.

The roll-off characteristics in three kinds which set the rate of a roll-off to alpha= 1.00.2and 0.1 are shown. When the rate of a roll-off is alpha(1-alpha) / from 2 to (1+alpha) / 2 become a field (transition region) of the shoulder characteristic which changes in the shape of a square cosine (raised cosine) with normalized frequency.

As long as it carries out distribution of the transfer characteristic to the transmitter of roll-off characteristicsand a receiver from the single purpose of losing intersymbol interferenceit may be arbitraryand as for a transmitter sidethe route roll-off filter of the square cosine which made the characteristic of the receiver end the same is usually used.

In the transmission-line composition of the route-off characteristic shown in drawing 12 (a)if an input signal can be sampled to right timinga transmission symbol sequence does not have intersymbol interference in a receiverand it is

known as the 1st standard of nyquist that it can restore thoroughly (if a sample point is right).
[0031]
In the block diagramshowing one gestalt of operation of this invention shown in drawing 1 (a) on the other handthe portion of 14 surrounded by the dotted line as a substantial transmission line is equivalent to the portion of 63 surrounded by the dotted line as a substantial transmission line in the block diagram showing the conventional single career communications system shown in drawing 12.
Thenit is considered that the translation data (OFDM signal) after IFT2 by the side of a transmitter is a transmission symbol sequence. The band limit which meets the 1st standard of nyquist by the route roll-off filters 3I3Q11Iand 11Q is applied to this transmission symbol sequenceAnd if the symbol synchronization is taken between transmitter-receivers and it samples to right timing by a receiverthe translation data (OFDM signal) after IFT2 and the input signal (OFDM signal) of FT12 in a receiver end are in agreement. FT12 in a receiver end outputs the same parallel complex symbol as the parallel complex symbol in front of IFT2 by the side of a transmitter. Thereforea complex transmission symbol sequence can be thoroughly restored in a receiver.
[0032]
It considered that the whole translation data (OFDM signal) after IFT2 was one transmission symbol sequenceand the band limit which meets the 1st standard of nyquist to this transmission symbol sequence is applied. Since M sampling points are contained at 1 symbol section of an OFDM signalthe access speed on appearance is M times. M is called point size of IFT2.
Thereforeif it band-limits by the roll-off filter of one M times the bandwidth of this and samples by a receiver end by M times as many sampling points (they are M sampling points during 1 symbol section of an OFDM signal)based on the output of this sampling pointthe complex transmission symbol of the one original series can be restored. Herethe sampling by M times as many sampling points is performed in the FT section 12. In the FT section 12the complex amplitude of the modulating signal which modulates each subcarrier which intersects perpendicularly by M times as many samplings is extracted.
Although based also on the signal configuration of OFDMthe point size of IFT2 is usually made equal to the number of subcarriers of an OFDM signal (L).
ThereforebelowM is also called number of subcarriers noting that the number of subcarriers (L) is equal to the point size (M) of IFT2in order to explain simply.
[0033]
The example in M= 4 is shown in drawing 1 (b). One symbol of one career is shown among OFDM signalsand the case where the sine wave 15 of one cycle is outputted in 1 OFDM symbol section is shown. A sampling period will be set to Ts/M=Ts/4 if section length of an OFDM symbol is set to Ts. If the transceiver filter which meets the 1st standard of nyquist by making one half of the reciprocals of a sampling period into a Nyquist rate (normalized frequency =0.5) is adoptedSince it has the impulse responses 16a-16d which carry out a zero

crossing by sampling period Ts/M as shown in a figureif a sample is carried out by a right sampling pointlike 17a-17da complex transmission symbol sequence does not have intersymbol interferenceand it is clear that it can restore thoroughly by a receiver.
Although the number of careers was set to 1 in drawing 1 (b)since linearity addition of the modulating signal corresponding to each career is only carried out in a transmission filter input even when making [two or more] the number of careersa complex transmission symbol sequence can be restored thoroughly similarly. Since the sampling period of an OFDM signal is Ts/Ma sampling frequency serves as M/Ts and a Nyquist rate serves as M/2Ts.
[0034]
The subcarrier of M book contained in an OFDM signal in the -6-dB pass band which has roll-off characteristics (it is from -0.5 to +0.5 at normalized frequency) is arranged. Among thesealthough it is easy to be influenced by band limit as the modulating signal of the subcarrier near the end of a zonesince the 1st standard of nyquist is satisfied by having roll-off characteristicsintersymbol interference is not produced to the modulating signal of the subcarrier near the end of a zone.
That a transmission symbol sequence can revert thoroughly is a case where there is no fixed degradation of a strain and radio equipment of noiseinterferenceand a propagation pathfor examplewhen there are fixed degradation and interference wavessuch as a sample timing errorrestoration of a transmission symbol sequence may become imperfect.
[0035]
The transmission power spectrum by this embodiment is calculated in the following procedures.
Introduction and the translation data sequence by which the parallel conversion was carried out are defined. Sign a_{mn} shows the n-th translation data sequence of the m-th subcarrier. f (t) is an impulse response of a route roll-off filter. When it is considered as the symbol interval (symbol section length of an OFDM signal) of the parallel symbol trains after serial parallel conversion [in / w_m can be set to the angular frequency of the m-th subcarrierand / in T_s / the transmitting side]the output of a spectrum plastic surgery filter (route roll-off filter) serves as a following formula.
[Equation 1]

The autocorrelation function R (t) of spectrum plastic surgery filter output v_1 (t) mentioned above is as a following formula.
[Equation 2]

The constant K is the impulse response length of a transmission filterand is

equivalent to the tap numbers of limited correlation length's digital filter (transversal filter).
Since power-spectrum P (w) is the Fourier transform of an autocorrelation functionit is given with a following formula.
[Equation 3]

in addition -- since it assumes using a digital filterthe integration in a formula (b) and (c) is discrete numerical integration -- the time interval of T_s/ M -- four points -- taking (4 time Oba thump) -- it carried out. That isthe sampling period was set to T_s/4Mand maximum frequency was made into two M/T_s.
[0036]
Drawing 6 is a graph which shows an output power spectrum at the time of using a route roll-off filter of rate of roll-off =0.2 for the transmitting side and a receiver.
Tap numbers of a filter were set to 101201 or 401.
As compared with an output power spectrum of the conventional OFDM signal shown in drawing 11a low out-of-band radiation level is attained. Compared with a case where signal band width carries out the multiplication of the conventional segment-of-time window as shown in drawing 11it turns out that it becomes about 60% by out-of-band radiation level 40 dB.
[0037]
When a digital filter realizes a route roll-off filter mentioned aboveit cannot but make from limited impulse response length. As a resultin order to close an impulse response on the way and for the close to make discontinuity generatedas shown in drawing 6an output power spectrum lengthens the long skirt and an out-of-band radiation level is increasing it.
Since power spectral density will decline quickly in a transition region if a rate of a roll-off is made smalland frequency utilization efficiency is raisedit is desirable.
Howeverlength of the skirt becomes long and an out-of-band radiation level becomes largeso that a rate of a roll-off is made small. Since time correlation length of an impulse response becomes longit is because influence of a truncation error becomes large as a rate of a roll-off with this small cause.
[0038]
Thenin a 2nd embodiment of this invention explained belowin order to reduce influence of the close mentioned abovean impulse response is optimized about a route roll-off filter by the side of a transmitter.
The comprehensive transmission characteristic of a transceiver filter obtained as a result of optimizing becomes a different thing from square cosine roll-off characteristicsand reduction of an out-of-band radiation level is realized under a condition in which the close of an impulse response exists.
As an example of concrete conditions of optimizationa comprehensive transmission characteristic with which (1) transmitting side and a receiver were doubled made a filter of meeting the 1st standard (with no intersymbol

interference) of nyquistand (2) receivers a route roll-off filter of an ideal square cosine.
[0039]
Drawing 2 is a block lineblock diagram for describing a 2nd embodiment of this invention.
Among a figurethe same numerals are given to the same portion as drawing 9 and drawing 1and explanation is omitted.
21I and 21Q are the spectrum plastic surgery filters which optimized an impulse response. The route roll-off filters 11I and 11Q of a receiver are the same as that of drawing 1.
[0040]
Drawing 3 is an explanatory view of a roll-off filter when an impulse response is optimized. Drawing 3 (a) is the 1st example of optimizationand drawing 3 (b) is an explanatory view of the 2nd example of optimization.
Normalized frequency (only a right side is shown) and vertical axis of a horizontal axis are output levels among a figure.
According to the 1st standard of nyquistto a point of the output level 0.5 (-6 dB) of cutoff frequency (Nyquist rate and normalized frequency =0.5) of an ideal low pass filterif the shoulder characteristic is an odd functionconditions without intersymbol interference will be fulfilled.
[0041]
In drawing 3 (a)31 is square cosine roll-off characteristics when it is considered as the rate alpha= 0.2 of a roll-offand is filter characteristics by which the 1st standard of nyquist is met. Although they meet the 1st standard of nyquistsince thingssuch as the rectangle characteristic (ideal low pass filter)the triangle characteristicand the trapezoid characteristicalso have a discontinuous point in inclinationand impulse response length increasesthey are not used.
In this embodimentthese square cosine roll-off characteristics 31 are made into a basic transfer function1 or two or more amendment transfer functions which are an odd function are further added to center frequency of a transition regionand an out-of-band radiation level is reduced here. Since the 1st standard of nyquist is metintersymbol interference is not produced.
In an example of drawing 3 (a)the outside boundary 32 (normalized frequency 0.6) of a transition region is set as a necessary zone and a border (frequency f_1) of being out of band. It is not necessary to necessarily do in this wayand frequency f_1 made into a necessary zone and a boundary of being out of band can be set up arbitrarilyand can carry out optimizing calculation.
Since outside boundary out-of-band radiation levels of a transition region as shown in drawing 3 (a) are few valuesin a power spectrum of a log scale later mentioned with reference to drawing 7 at a linear scale although it is hard to identify a difference of a transfer function after amendmentand the square cosine roll-off characteristics 31it is discriminable.
The spectrum plastic surgery filters 21I and 21Q of the transmitting side serve as the characteristic to which a part of comprehensive transmission characteristic

was distributed. Thereforethe characteristic is expressed with a transfer function which did division of the transfer function of a comprehensive transmission characteristic with a transfer function of a receiving filter. As an amendment transfer functionsaid 1 or two or more amendment transfer functions in said transition region turn into the oddth cosine functionand a transfer function of a comprehensive transmission characteristic is continuing in each frequency of both ends of said transition region.

[0042]

The comprehensive transmission characteristic F (w) of a transmission filter and a receiving filter in this embodiment is as a following formula. w is angular frequency and takes a value of positive/negative. p is a degree and a coefficient [in / in alpha$_p$ / the degree p]and alpha$_p$F$_p$ (w) is a frequency characteristic in each degree p (Pth less than order more than per order).

a case of $F_0(w)+F_1$ (w) -- the conventional square cosine roll-off characteristics -- it becomes.

[Equation 4]

Heretotal of coefficient alpha$_p$ in each degree p (Pth less than order more than per order) is 1. namely

[Equation 5]

[0043]

Formulas (2) are conditions for a frequency characteristic to become continuously on both sides of a transition region.

The formula (1) and (2) is transformed and a following formula (3) is obtained.

[Equation 6]

It is here

[Equation 7]

[Equation 8]

The formula (4) and (5) mentioned above shows F_0 (w) in a formula (3)and F_1 (w). It is a symbol interval (symbol section length of an OFDM signal) of parallel symbol

trains after serial parallel conversion [in / M / alpha can be set to a rate of a roll-offand / in the number of subcarriers (total)and T_s / the transmitting side].
In the case of P= 1 (namelysum at the time of p= 0 and 1)it becomes the conventional square cosine roll-off filter shown in 31 of drawing 3 by a formula (1).
F_p (w) (p>=2) It is F_p (w) (p= 1) in order to optimize an impulse response (an out-of-band radiation level is reduced). It is the extended function.
[0044]
That isthe conventional square cosine roll-off filter is using cosine function cos(x) as the shoulder characteristic (transition characteristic) between a band pass and a cutoff frequency zone. In the comprehensive transmission characteristic of a transceiver filter in this embodiment. As the shoulder characteristicthey are the oddth cosine (cosine) set of functions (cycle of 1 part odd of a fundamental period)i.e.cos(x)cos (3x)and cos (5x). -- Combination of cos [(2P-1) x] is used.
Drawing 4 is a graph which shows F_p (w) when it is considered as the rate alpha= 0.2 of a roll-off. It unites and F_0 (w) is illustrated. Although a field negative in normalized frequency is not illustratedit is symmetrical with positive/negative.
A cosine set of functions mentioned above is all an odd function to the center (normalized frequency 0.5) of a transition region so that clearly from drawing 4.
Thereforeconditions without intersymbol interference are fulfilled and a thing also as used in the field of an extended square cosine roll-off filter is realized.
[0045]
It asks for an out-of-band radiation level of a sending signal in this embodimenti.e.a sending signal which a spectrum plastic surgery filter outputsand an output power spectrum at the time of setting up coefficient $alpha_p$ in the degree p so that this out-of-band radiation level may serve as the minimum is searched for.
According to this embodimenta filter (11I11Q of drawing 2) of a receiver was assumed to be the ideal route roll-off (root roll-off) characteristic (roll-off characteristics of a square cosine). Thereforeif division process of the comprehensive transmission characteristic of a formula (1) mentioned above is carried out in the characteristic (ideal route roll-off characteristics) of a receiverthe filter characteristics of the transmitting sidei.e.the characteristic of the spectrum plastic surgery filters 21I and 21Q of drawing 2can be found.
[0046]
When the filter characteristics of the transmitting side are set to G (w)it is as a following formula.
[Equation 9]

HereG$_1$ (w) in a formula (6) and G_p (w) are as a following formula. G_1 (w) of a formula (7) is ideal route roll-off characteristics.
[Equation 10]

[0047]
When G (w) of the formula (6) mentioned above is made into the characteristic of a transmission filterthe output power spectrum P (w) serves as a following formula. The derivation process of expression is skipped.
[Equation 11]

Herec (w) and Hp (w) are as a following formula.
[Equation 12]

w_m in a formula (10) and (11) Angular frequency of the m-th subcarrierA symbol interval (symbol section length of an OFDM signal) of parallel symbol trains after serial parallel conversion in the transmitting side and the constant K are the impulse response length of a transmission filterand T_s is equivalent to tap numbers of limited correlation length's digital filter (transversal filter).
[0048]
Since it is obtained by integrating with an output power spectrum of a formula (9) in the number of out bandsthe out-of-band radiation level Pt is given like a following formula.
[Equation 13]

They are the angular frequency defined as w_1 being inside of the zone in the case of optimizationand the boundary of being out of band here as already explainedand the highest angular frequency it is decided from the sampling theorem that w_2 will be. If frequency f_1 defines this boundary and frequency will define $f_1=w_1/2pi$and highest angular-frequency $w_2$it will be given by $f_2=w_2/2pi$. If are premised on a digital filter and maximum frequency will be 1 / 2 or 4 time over sampling of a sampling frequencysince a sampling frequency is 4 in normalized frequencymaximum frequency will be set to 2.
Since a formula (12) mentioned above is a secondary function of each $alpha_p$ (p>=2) (the multiplication of $alpha_p$ and the $alpha_q$ is carried out about p= 2--Pq= 2--P) and all of a secondary coefficient are positivethe extremum gives the minimum of an out-of-band radiation level. Calculate a value of each $alpha_p$ (p>=2) which gives an extremum in each formula which differentiated a formula (12) about each $alpha_p$ (p>=2)substitute these for (2) typesobtain $alpha_1$and further with this $alpha_1$. (6) If the Fourier transform is substituted and carried out to a formulaan impulse response which makes an out-of-band radiation level the minimum can be

found.
[0049]
As shown in drawing 3 (b)the steep characteristic almost same as the roll-off characteristics 35 at the time of setting the boundary 34 to frequency f_1=0.55 as a case where it is considered as the rate alpha= 0.1 (transition region 0.45<=f<=0.55) of a roll-off is obtained.
That issince a coefficient was set up so that a radiation level of a zone outside frequency f_1 of the boundary 34 might become the minimumamplitude of an outside transmission filter transmission characteristic is remarkably reduced from frequency f_1=0.55 of the boundary 34. This is clear if an output power spectrum after optimization shown in drawing 7 (b) mentioned later is compared with an output power spectrum without amplitude control of drawing 12. Amplitude of an outside comprehensive transmission characteristic is remarkably reduced from frequency f_1 as a result. Since a comprehensive transmission characteristic maintains the characteristic which serves as an odd function before and behind a point of the output 0.5 (-6 dB) of a Nyquist rate (normalized frequency 0.5)it is set to about 1.0 (0 dB) in frequency f= 0.45. As a resultthe same steep transition characteristic as a case where it is considered as the rate alpha= 0.1 (transition region 0.45<=f<=0.55) of a roll-off is obtained. And since an out-of-band radiation level from frequency f_1 of this boundary 34 is the minimumcompared with a case where a digital filter realizes the mere rate alpha= 0.1 of a roll-offan out-of-band radiated power level becomes small.
[0050]
When it is referred to as frequency f_1=0.55 of tap-numbers =201 of a digital filterthe rate alpha= 0.2 of a roll-offand a boundaryand P= 5 (it is to the 9th order as a degree of a cosine function) with the Oba sample career several M= 64 or 4 timesthe $alpha_p$ (1<=p<=5) is as follows.
$alpha_1$=1 - ($alpha_2$+$alpha_3$+$alpha_4$+$alpha_5$)
$alpha_2$=0.308400406
$alpha_3$=-0.100279167
$alpha_4$=0.025005514
$alpha_5$=-0.00326821691
[0051]
Drawing 5 is a graph which shows impulse loess HONSU of the spectrum plastic surgery filters 21I and 21Q of the transmitting side when an out-of-band radiation level is made into the minimum. Sample timing and vertical axis of a horizontal axis are output values (linear scale) among a figure. The spectrum plastic surgery filters 21I and 21Q carry out the multiplication of the tap coefficient to an output of each tap of a serialized delay elementrespectivelyfor exampleand are realized by transversal filter (FIR filter: limited length impulse response filter) which adds and outputs each multiplication result. In this casea value of an impulse response mentioned above gives a tap coefficient when a horizontal axis is made into tap numbers. As already explained201 taps show a case where over sampling is performed 4 times.

Although D/A conversion of the output of the spectrum plastic surgery filters 21I and 21Q is carried outSince it becomes a rectangle instead of an impulsean output of a D/A converter can be disregarded as a matter of fact according to what is called an aperture effectif a rate of the Oba sample is highalthough a high region of the comprehensive transfer characteristic of a substantial transmission line will fall. What is necessary is just to compensate the characteristic in these spectrum plastic surgery filters 21I and 21Qfor examplewhen it cannot ignore.

[0052]

Drawing 7 is a figure showing an output power spectrum when it optimizes so that an out-of-band radiation level may become the minimum. It is the characteristic in the same setups as drawing 6.

A case where frequency f_1=0.6 defined as a necessary zone and a boundary of being out of bandand drawing 7 (b) set drawing 7 (a) to f_1=0.55 is shown.

An output power spectrum of a semi- rectangle which does not have a side lobe by optimization was acquired. Although power flux density is lengthening the skirt in not more than -100dBit has become outside of the range of a graphic display. As a comparative examplea case of a square cosine roll-off filter which is a 1st embodiment is shown.

In drawing 7 (b)since a signal band whereas for a signal band where an out-of-band radiation level will be -40dB1.06 times of a Nyquist rate and an out-of-band radiation level will be -60dB is only 1.08 times the Nyquist ratefrequency utilization efficiency is improved remarkably. An out-of-band radiation level lower than a case where the multiplication of the conventional segment-of-time window which was illustrated to drawing 11 is carried out for whether your being Haruka is attained.

[0053]

Drawing 8 is a graph which shows the number dependency of careers of an output power spectrum in a 2nd embodiment. The career M [several] was made into three kinds1632and 64. It turns out that out-of-band radiation levels decrease in number with an increase in the number of careers. It decreases remarkably on 64 careers. When there are too much few careersit is necessary to increase tap numbers of a filter.

[0054]

In explanation mentioned aboveit was considered more than as the 3rd oddth cos set of functions (cos (3x) and cos(5x) --) as a function (amendment transfer function) added to a function (basic transfer function) of square cosine roll-off characteristics. On a principleif it is a set of functions which serves as an odd function to a Nyquist ratea coefficient of a set of functions can be optimized so that it may become a filter which fulfills the 1st condition of nyquist and an out-of-band radiation level may be reduced.

Thereforebasic transfer functions other than an example mentioned above and an amendment transfer function may be adopted. For examplea sine (sin) set of functions can be used as an amendment transfer function. What combined a sin set of functions and a cos set of functions mentioned above may be used.

It may have imaginary partalthough a function which consists only of real parts was used as a function added to a function of roll-off characteristics. Also when imaginary part serves as an even function to a Nyquist ratemeeting the 1st standard of nyquist is known.

[0055]

In explanation mentioned abovealthough the number of subcarriers (L) usually presupposes that it is equal to a point size (M) of IFT2arbitrary numbers of subcarriers may not be intentionally used for it for avoiding mutual interference between other communications systems etc. Even in such a casesince a point size (M) of IFT2 does not changeits value of L and M does not necessarily correspond.

[0056]

In explanation mentioned abovesince an OFDM communication system used for a wireless LAN system was explained as a premiseit becomes the complex signal mapped in accordance with a digital modulation rule as transmitting complex symbol trains. Howevercode spread of the complex signal mapped in accordance with a digital modulation rule as transmitting complex symbol trains may be carried out to a time base direction with a spread code. Or code spread of the spread code may be assigned and carried out in the direction of a frequency axis (arrangement direction of a subcarrier)and a complex amplitude level of a subcarrier by which serial parallel conversion was carried out may be outputted to IFT. Thusa transmitting complex symbol before being inputted into IFT may be anything.

A use of a communications system is not restricted to wireless LAN. It may apply to at least one communications system of going up in a communications system between mobile station base stations in mobile radio communication networkssuch as a cellular phoneand a going-down transmission line.

[0057]

Although a filter of this invention was applied [explanation / which was mentioned above] to a transmission filter of an OFDM communication systemwhile using it for other uses and being satisfied of the 1st standard of nyquistit is also possible to reduce an out-of-band output-signal-power level. For exampleit can apply to a cable or an optical-communications baseband communications system using a signal of only a real part of a binary or a multiple valuewithout using digital modulation.

The technique of correcting a transfer function which is to foundations which take part of responsibility for the characteristic which meets the 1st standard of nyquist using 1 or two or more transfer function groups which meet the 1st standard of nyquist is also employable for the purposes other than out-of-band radiation level reduction.

[0058]

[Effect of the Invention]

So that clearly from the explanation mentioned above the sending set of this inventionIt is effective in the radiated power level besides a necessary zone decreasingwithout reducing an out-of-band radiated power level's satisfying the

1st standard of nyquistand producing intersymbol interference in the communications system which transmits the difficult OFDM signal created by IFT. The filter device of this invention is used as transmission filterssuch as a communications system mentioned aboveand it is effective in the radiated power level besides a necessary zone decreasingwithout satisfying the 1st standard of nyquist and producing intersymbol interference.

[Brief Description of the Drawings]

[Drawing 1]It is an explanatory view of a 1st embodiment of this invention. Drawing 1 (a) is a block lineblock diagramand drawing 1 (b) is an explanatory view of operation.

[Drawing 2]It is a block lineblock diagram for describing a 2nd embodiment of this invention.

[Drawing 3]It is an explanatory view of the roll-off filter which optimized the impulse response.

[Drawing 4]It is a graph which shows F_p (w) when it is considered as the rate alpha= 0.2 of a roll-off.

[Drawing 5]It is a graph which shows impulse loess HONSU of the spectrum plastic surgery filters 21I and 21Q when an out-of-band radiation level is made into the minimum.

[Drawing 6]It is a graph which shows the output power spectrum at the time of using the route roll-off filter of the rate 0.2 of a roll-off for the transmitting side and a receiver.

[Drawing 7]It is a figure showing an output power spectrum when it optimizes so that an out-of-band radiation level may become the minimum.

[Drawing 8]It is a graph which shows the number dependency of careers of the output power spectrum in a 2nd embodiment.

[Drawing 9]It is a block lineblock diagram of the conventional OFDM communication system.

[Drawing 10]It is an explanatory view of the window function for explaining the amplitude control by the side of a transmitter in the conventional OFDM communication system.

[Drawing 11]It is a graph in the conventional OFDM communication system which shows an output-signal-power spectrum.

[Drawing 12]It is a graph which shows the conventional block lineblock diagram and roll-off characteristics of a single career communications system.

[Description of Notations]

1 -- A deserializer2 -- The IFT (inverse Fourier transform) section3I3Q -- The route roll-off filter by the side of a transmitter4I4Q [-- Transmission line] -- A multiplier5 -- A carrier signal oscillator6 -- An adding machine7 8 [-- The route roll-off filter of a receiver end12 / -- The FT (Fourier transform) section13 / -- A serializer21I21Q / -- Spectrum plastic surgery filter which optimized the impulse response] -- A tee9I9Q -- A multiplier10 -- A carrier signal oscillator11I11Q

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